Radiation Physics Note 68

Calibration of the N01 Stack Monitor

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March 1988

The Neutrino target train located in enclosure N01 is known to activate the surrounding air as a result of irradiation by 800 GeV protons. The air is ventilated from the enclosure at a single exhaust stack. As part of the environmental monitoring program, this gaseous radioactive effluent is continuously sampled and results are recorded via the MUX data logger.

The monitoring instrument consists of an Eberline RM-14 ratemeter and a GM thin window "Frisker" probe. The probe is sealed inside a 2.25 liter lead shielded canister, through which air is pumped from the exhaust stack. The GM probe primarily detects the beta decay of any accelerator produced radioisotopes which may be present. C-11, N-13 and traces of O-15 have been previously identified at N01 during the Triplet target train operation (Bu88). The monitoring system is located in the NS1 service building. Air is drawn through a 1/4" I.D. by approximately 350 foot long Tygon tube which runs through the enclosure between the stack and the sampler. (See Figure 1.) Flow rate is typically 4-6 lpm, which implies that the air travels from the stack to the sampler in less than 1 minute.

In December 1987 during the fixed target run program, the GM based sampler (Stack Monitor, serial number 9484 and RM-14 unit #3) was cross calibrated against a Johnston Laboratories Triton 955B ion chamber, unit #4. This latter instrument is routinely calibrated against a known activity of tritiated methane by the Fermilab Instrument Maintenance and Calibration Group, IMAC.

The basic procedure used for the cross calibration was to connect the exhaust hose from the GM system to the intake of the Triton. The GM system's air pump was turned off and air was pulled through both samplers by the Triton air pump. Air flow was regulated at both units' flow meters to 4 lpm. A diagram of the setup is shown in Figure 2. Both the Triton and GM stack monitor were inputted to the MUX system and remained in this serial configuration from 12/2/87 to 12/21/87. During the first week of this period, the Neutrino Triplet Train was typically targetted with 2-4E12 protons per pulse, on a 56.3 second cycle time.

The Triton was set to the H3 (tritium) scale on a x10 multiplier. Triton response to accelerator produced air radionuclides is assumed to be a factor of 5 greater than for tritium (Pe72). Therefore, the full scale of the instrument is 100/5 = 20 pCi/ml. The recently installed MUX interface was set to provide a 30 Hz rate at full scale. The GM based system initially had it's RM-14 ratemeter response attenuated by a divide by 100 factor. This gave a very low count rate and was **changed to a divide by 1 rate on 12/4/87** at about 1300 hours. It was **changed again on 12/22/87 to a divide by 10 count rate** and left this way until the fixed target program ended on 2/15/88.

The count rate of both air samplers was integrated in both 1 hour and 8 hour increments in the MUX reports. Triton counts were converted to units of activity concentration and divided by the GM system's count rate for the same time period, to obtain a calibration factor, K. The data is summarized in Table 1. Several one hour data points were also chosen as they represent peak rates observed during this study period. A sample calculation follows:

$$K = \frac{(19825 \text{ Triton cts}/3600\text{sec}) \times (20 \text{ pCi/ml} / 30 \text{ cts/sec})}{17320 \text{ GM cts/hr}} = 2.12\text{E-4 pCi/ml/ct/hr}$$

Figure 3 shows a plot of the calibration factor, K versus activity concentration as measured by the Triton. Clearly, the K factor increases linearly as activity concentration increases to about 8 pCi/ml. It then appears that the value of K levels off at about 2.35E-4 pCi/ml/ct/hr. This appears to be due to some nonlinearity in one or both of counting electronics systems.

It is concluded from these measurements that a **K factor of 2.4E-4 pCi/ml/ct/hr should be used** when the RM-14 uses the divide by 1 scale setting. **Prior to 4 December 1987,** when the RM14 system used a divide by 100 scale setting, **a K factor of 0.024 applies. After 22 December, a K factor of 2.4E-3 should be used.** In order to avoid confusion in the future, it is recommended that a single universal scale setting be used for the Stack Monitor Ratemeters. It seems best to **use the divide by 100 scale** since it gives adequate sensitivity and is least likely to cause MUX to go off scale in the unlikely event of an abnormally high concentration release.

As a further point of interest, a plot was made of the activity concentration measured at the stack as a function of proton target intensity. A very linear response can be seen in Figure 4. The activity release rate at the stack can be estimated by selecting a point on the curve and normalizing to an 800 GeV proton on the Triplet target.

$$\frac{10\ \text{pCi/ml} \times 800\ \text{ft}^3/\text{min} \times 60\ \text{min/hr} \times 2.83\text{E}4\ \text{ml/ft}^3}{4.4\text{E}12\ \text{protons/pulse} \times 60\ \text{pulses/hr}} = 5.15\text{E-}17\ \text{Ci/proton}$$

The 800 CFM value is the stack exhaust rate measured in June 1987 by S. Butala and K. Horsey, following the installation of a lower speed fan. This gives an estimated release of 27.2 Ci for the 5.28E17 protons targeted in 1987. A total of 1.16E17 protons were targeted in 1988 which implies a stack release of 6.0 Ci. Both beam intensity figures are for NCenter fast spill as measured by the NC1TOR toroid and supplied by Dan Johnson and Romesh Sood of the R.D. Site Operations Department.

References

Bu88 S. Butala, Air Activation Measurements at N01 Enclosure. Memo to S. Baker, 1/4/88.

Pe72 A. Peetermans, 1972 CERN Report 72-12, Geneva, Switzerland

FIGURE 1 - NEUTRINO ENCLOSURE N01

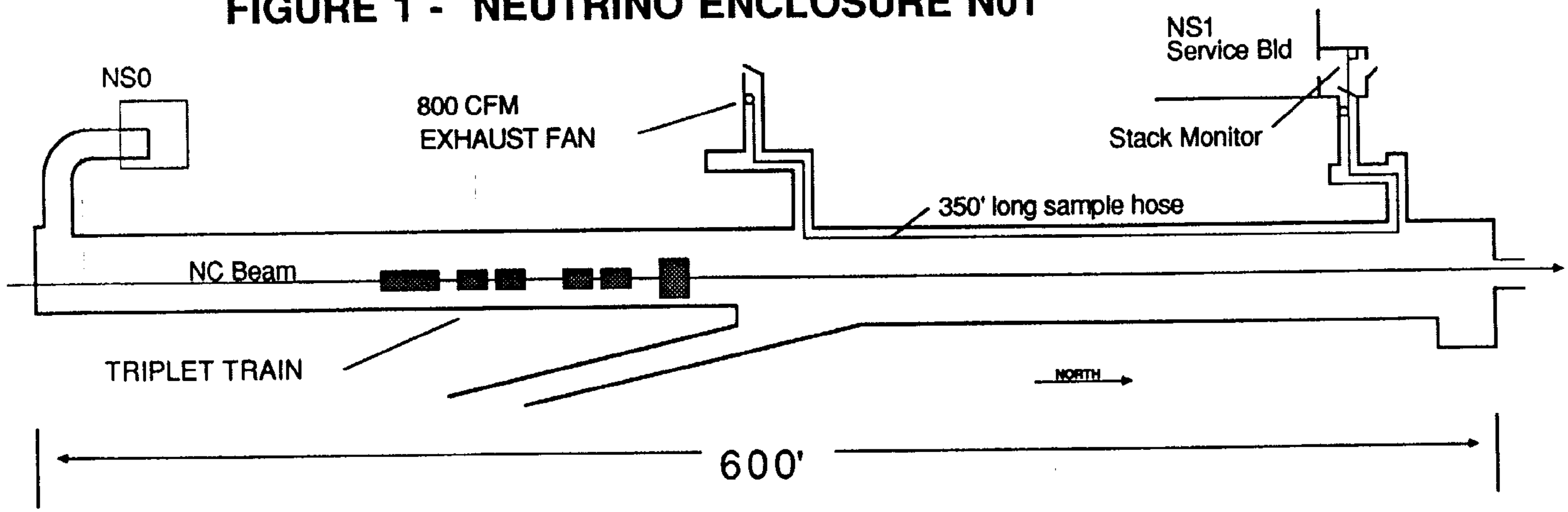

FIGURE 2 - Triton/RM14 Stack Monitor Cross Calibration

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8 February 1988

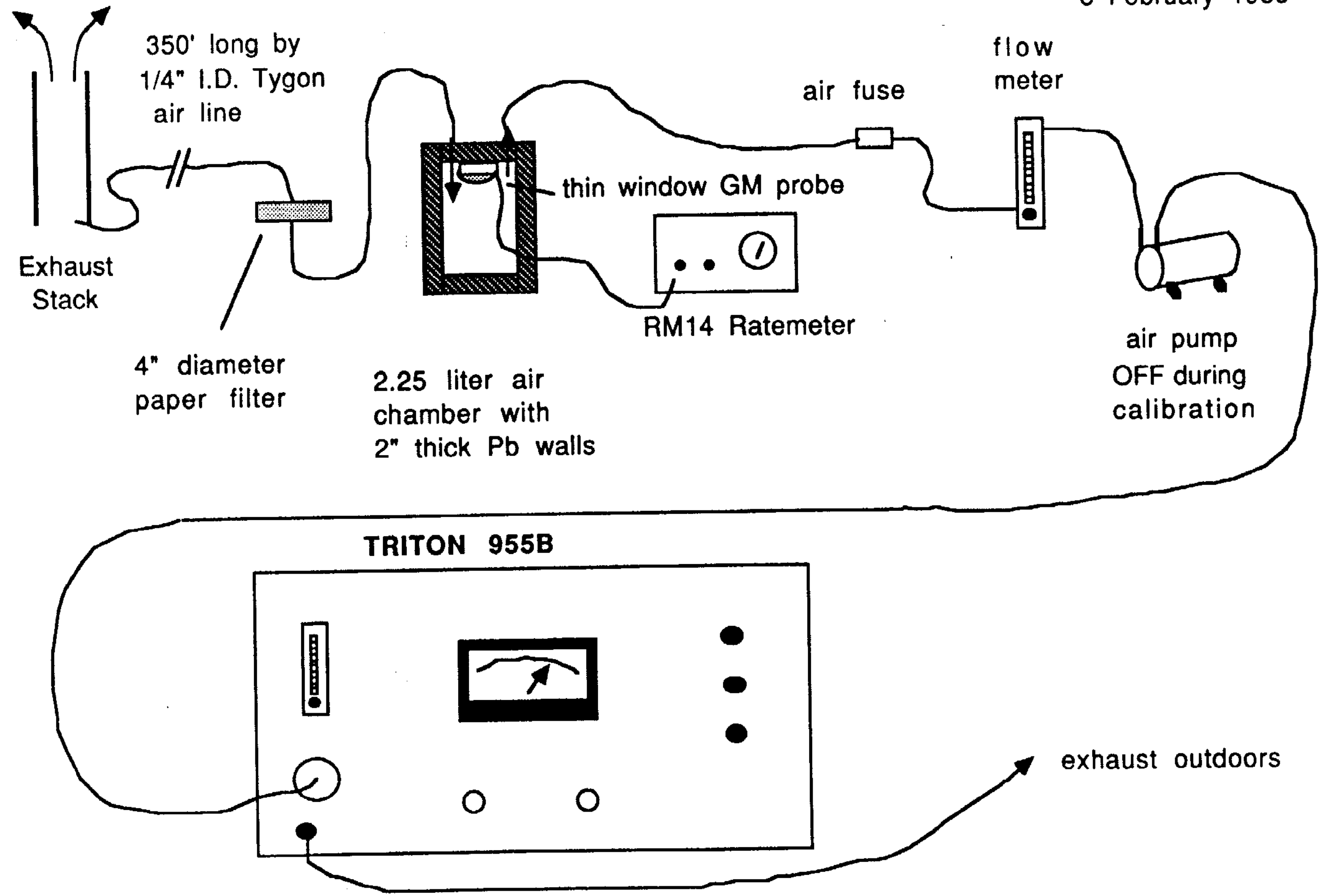
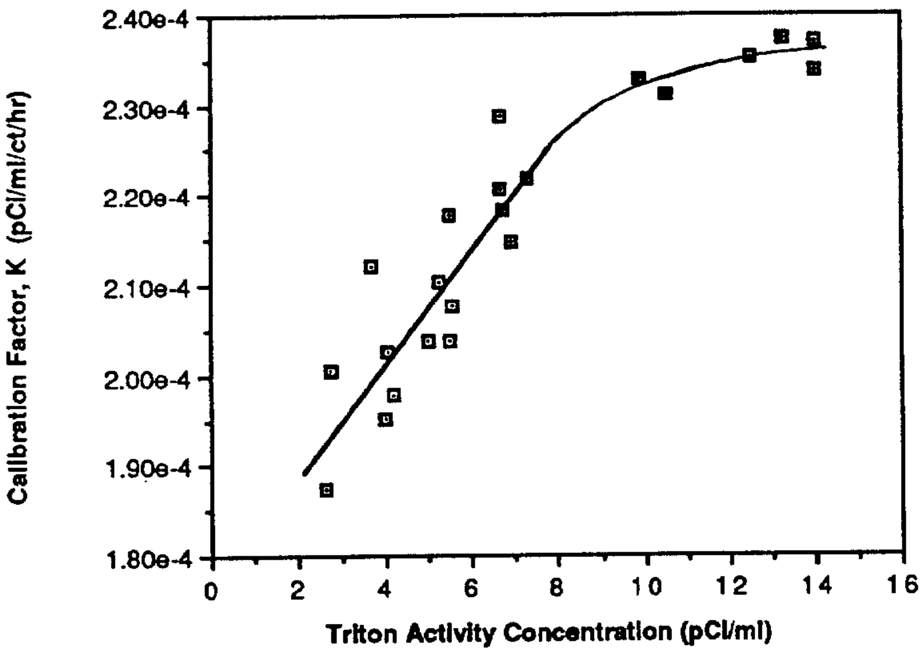


Figure 3 - N01 Triton/RM14 Stack Monitor Calibration



Data from 12/87. Triton #4 on H3 x10 scale. RM14 on cts/1 scale.

Figure 4 - N01 Triton Response vs. NC Beam Intensity

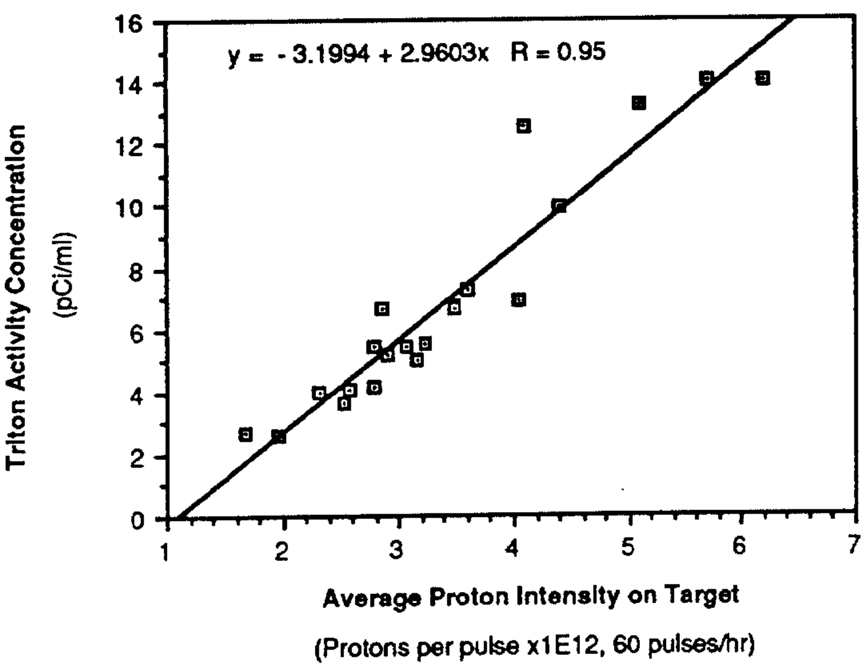


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TABLE I - N01 Triton/SM Cal-A

	Date/Time	NCF avg ppp (x1E12)	Triton cts/hr	Triton Conc (pCi/ml)	RM14 Raw	RM14 cts/hr	Cal Factor
1	12/4	2.53	19825	3.671	19320	17320.000	2.120e-4
2	12/5	1.95	14164	2.623	15994	13994.000	1.874e-4
3	12/5	2.78	22461	4.159	23030	21030.000	1.978e-4
4	12/5	3.15	26919	4.985	26457	24457.000	2.038e-4
5	12/6	3.22	30061	5.567	28821	26821.000	2.076e-4
6	12/6	2.85	35852	6.639	31025	29025.000	2.287e-4
7	12/6	3.48	36271	6.717	32753	30753.000	2.184e-4
8	12/7	3.48	35905	6.649	32138	30138.000	2.206e-4
9	12/7	2.79	29451	5.454	27053	25053.000	2.177e-4
10	12/7	4.04	37321	6.911	34172	32172.000	2.148e-4
11	12/8	1.67	14654	2.714	15545	13545.000	2.004e-4
12	12/8	3.61	39295	7.277	34780	32780.000	2.220e-4
13	12/8	4.41	53551	9.917	44597	42597.000	2.328e-4
14	12/9	3.07	29503	5.464	28808	26808.000	2.038e-4
15	12/9	2.31	21369	3.957	22269	20269.000	1.952e-4
16	12/10	2.91	28255	5.232	26886	24886.000	2.102e-4
17	12/11	2.58	21908	4.057	22026	20026.000	2.026e-4
18	12/8 @ 1730	6.20	75579	13.996	61895	59895.000	2.337e-4
19	12/8 @ 1830	5.70	75610	14.002	61101	59101.000	2.369e-4
20	12/8 @ 1930	5.10	71504	13.241	57778	55778.000	2.374e-4
21	12/8 @ 2030	4.10	67578	12.514	55203	53203.000	2.352e-4